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NETWORKS TO PROMOTE COLLABORATION ON THE FRONT END OF INNOVATION: A SYSTEMATIC LITERATURE REVIEW

REDES DE PROMOÇÃO ÀS COLABORAÇÕES NO FRONT END DA INOVAÇÃO: UMA REVISÃO SISTEMÁTICA DA LITERATURA

REDES PARA PROMOVER COLABORACIONES EN FRONT END DE LA INNOVACIÓN: UNA REVISIÓN SISTEMÁTICA DE LA LITERATURA

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Abstract

Objective: Based on international scientific literature, the research seeks to understand the interface between the subjects of networks, collaborations, and the front end of innovation (FEI).
Methodology/approach: Two systematic reviews were carried out, seeking articles published from 2010 onward in the EBSCO, Scopus, and Web of Science databases.
Originality/Relevance: The article contributes to studies within the themes of networks, especially focused on collaboration that support the front end of innovation. The research was limited to understanding networks in the context of entrepreneurship. Therefore, there is opportunity for future analysis in other contexts.
Main results: The study selected 49 articles published from 2010 onward, revealing complementarity within the fields studied.
Theoretical/methodological contributions: The articles that discuss the context of collaboration in the front end of innovation address topics that are interconnected, such as "social networks," "theory of knowledge," and "open innovation."
Social/management contributions: It was possible to identify elements that influence a network, such as the region's cultural and material structure, and aspects regarding the relationships established in the network, particularly individual predispositions and the strength of the ties.

Keywords: Collaboration. Front end of innovation. Networks. Entrepreneurship.

Resumo

Objetivo: A pesquisa busca compreender, a partir da literatura científica internacional, a interface entre as temáticas de redes, colaborações e front end da inovação (FEI).
Metodologia/abordagem: Foram realizadas duas revisões sistemáticas, buscando-se artigos publicados a partir de 2010 nas bases de dados EBSCO, Scopus e Web of Science.
Originalidade/Relevância: O artigo contribui para estudos dentro das temáticas de redes, especialmente voltadas para as colaborações que apoiam o front end da inovação. Porém, a pesquisa

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limitou-se à compreensão das redes no contexto do empreendedorismo, oportunidade para análises futuras em outros contextos.
Principais resultados: Ao total, 49 estudos publicados nesse período foram selecionados para análise, que mostraram a complementaridade das temáticas estudadas.
Contribuições teóricas/metodológicas: Constatou-se que os artigos que debatem o contexto das colaborações no front end da inovação acabam abordando temáticas que, inclusive, possuem interligação entre si, como "redes sociais", "teoria do conhecimento" e "inovação aberta".
Contribuições sociais/para a gestão: Foi possível identificar elementos que influenciam uma rede, como a estrutura cultural e material da região, bem como aspectos voltados aos relacionamentos estabelecidos na rede, em especial as predisposições individuais e a "força" dos laços desenvolvidos.

Palavras-chave: Colaboração. Front end da inovação. Redes. Empreendedorismo.

Resumen
Objetivo: La investigación busca comprender, a partir de la literatura científica internacional, la interfaz entre los temas de redes, colaboraciones y front end of innovation (FEI).
Metodología/enfoque: Se realizaron dos revisiones sistemáticas buscando artículos publicados a partir de 2010 en las bases de datos EBSCO, Scopus y Web of Science.
Originalidad/Relevancia: El artículo contribuye a los estudios dentro de los temas de las redes, especialmente centrado en las colaboraciones que apoyan el front end de innovación. Sin embargo, la investigación se ha limitado a la comprensión de las redes en el contexto del emprendimiento, una oportunidad para el análisis futuro en otros contextos.
Principales resultados: En total, 49 estudios publicados en este período fueron seleccionados para el análisis, que ha mostrado la complementariedad de los temas estudiados.
Aportes teóricos/metodológicos: Se ha encontrado que los artículos que discuten el contexto de las colaboraciones en el front end de la innovación terminan abordando temas que incluso tienen interconexión entre sí, como "redes sociales", "teoría del conocimiento" y "innovación abierta".
Aportes sociales/de gestión: Fue posible identificar elementos que inciden en una red, como la estructura cultural y material de la región, así como aspectos enfocados en las relaciones que se establecen en la red, especialmente las predisposiciones individuales y la "fuerza" de los lazos desarrollados.

Palabras clave: Colaboración. Front end de la innovación. Redes. Emprendimiento.

Introduction

Innovation studies have brought new perspectives and elements to improve innovation processes. One of the main drivers promoting this subject is that innovation is a primary source of economic growth (Tidd & Bessant, 2015).

In Brazil, the Innovation Survey (Pintec) conducted from 2015 to 2017 by the Brazilian Institute of Geography and Statistics (IBGE) showed that 80% of the participating companies pointed out the excessive economic risks as the main obstacle hindering their engagement in innovation processes. The second most important obstacle mentioned was the high costs of innovation. Both factors are related to the innovation process, particularly in its first stage, marked by uncertainties.

Therefore, organizations have been investing in activities that foster innovation. Many of these activities are carried out internally, resulting from actions by innovation teams or

research and development departments (Kline & Rosenberg, 2015). Furthermore, the importance of companies "opening their doors" to ideas and external contributions from the market – the so-called 'open 'innovation' – is currently being discussed (Chesbrough, 2003). Such a strategy emphasizes the integration of multidisciplinary knowledge through the construction of complementary internal networks (Petroni et al., 2012, as cited in Pateli & Lioukas, 2019).

Taking Open Innovation to the practical side, Lau, Hirsch, Matheis, Fischer, and Kettemann (2016, p. 2) mention that "the focus lies to-date on successful ways to integrate partners, mainly customers, in the phase of idea generation." This initial stage of developing a venture has received special attention from recent research and is named the front end of innovation (FEI).

In this context of open innovation as an important foundation in innovative processes, the collaboration of external actors is presented as a promising alternative in this initial stage. Schweitzer and Gabriel (2012, p. 13) concluded that "the quality of collaboration has a significant and positive effect on all front-end success factors," from factors such as creativity, efficiency, and even the reduction of technical uncertainties. Likewise, Wagner, Bican, and Brem (2021) identified that external collaboration, whether with customers, intermediaries, suppliers, or competition, is an important indicator of front end success. However, Elerud-tryde and Hooge (2014) concluded that more research is needed to understand how collaborative tools can support the efficient generation of ideas and innovation.

Initially, the study sought to deepen the understanding of how collaboration occurs at the FEI through a systematic literature review. The databases consulted were EBSCO, Scopus, and Web of Science using the search terms 'collaboration,' 'innovation,' and 'front end of innovation.'

A preliminary reading of the studies selected from the systematic review expanded the perspectives of understanding collaboration at the FEI, bringing new relevant peripheral themes, including the issue of networks. The concept of innovation networks is currently popular "as it appears to offer many of the benefits of internal development, but with few drawbacks of collaboration" (Tidd, Bessant, & Pavitt, 2008, p. 327). However, few studies address the relevance of stakeholder involvement in the FEI (Bendavid & Bourgault, 2010).

Thus, the research problem was redefined, considering networks as important elements for understanding the phenomenon. In this sense, the research question was expanded to: How can networks promote collaboration in the FEI? Therefore, a second systematic literature

review was carried out using the same databases, deepening the understanding using the search terms ‘entrepreneurship,’ ‘innovation,’ and ‘social networks.’ The term entrepreneurship was added to find research on networks within the perspective of innovation processes. The two literature reviews resulted in 49 articles that were analyzed in full.

Therefore, this study seeks support from the international scientific literature to understand the interface between the themes of networks, collaboration, and FEI, based on the complementarity of the studies selected in the literature reviews. The study contributes to the systematization of the findings, referring to the researched constructs to guide works with this focus.

After this introduction, this article presents the research’s theoretical framework and methodology. The fourth section presents the results, followed by the discussion in the fifth and final section.

Theoretical framework

This article’s theoretical framework is based on approaching broader concepts to understand the context, address the innovation process, and assess the current importance of open innovation. Next, the research aims to comprehend the front end of innovation (FEI) and how collaboration can impact its results. Finally, some relevant concepts related to the theme of networks are explored.

The vision of innovation as the main source of economic growth (Tidd & Bessant, 2015) means that the topic has been studied tirelessly to understand how organizations can optimize their internal processes, generate more innovation, and, consequently, important financial results. For Schumpeter (1982), the meaning given to development is directly linked to the realization of “new combinations.” In other words, the author argues that it is necessary to explore existing and new resources, giving a different purpose to market needs.

For Kline and Rosenberg (2015) several sources feed the innovation process, generally related to knowledge areas, sectors, and economic actors. The authors propose the chain-linked model, in which they assume that innovation originates from different sources and its process is iterative, involving external actors in capturing knowledge and feedback.

Therefore, companies begin to think about ways to interact and cooperate with external agents and understand the importance of customers, suppliers, universities, and other actors in the ecosystem to acquire knowledge. Therefore, open innovation “means that valuable ideas

can come from inside or outside the company and can go to market from inside or outside the company" (Chesbrough, 2003, p. 43).

Regardless of the source of new ideas or the results achieved, innovation is a process. Kline and Rosenberg (2015) observe that innovation is neither a linear nor a regular process. It needs an adequate model to offer consistency to a path to be followed. The authors also argue that the central dimension that organizes innovation is uncertainty because innovating implies creating the new, and the new contains elements that we do not understand at the beginning and that are, consequently, uncertain.

Therefore, following a process can facilitate and reduce uncertainties. Smith and Reinertsen (1991, as cited in Teza et al., 2015) present three stages of the innovation process: the fuzzy front end – called here the front end of innovation (FEI), the new product development (NPD) process, and, finally, commercialization.

The front end of Innovation (FEI), a term coined by Koen et al. (2001), is the stage that comprises activities preceding the solution design. This stage of innovative processes is considered in the literature as the most uncertain and chaotic of the three stages. Currently, the literature on innovation has dealt little with the initial stage, the FEI, according to Teza et al. (2015). This stage comprises activities such as identifying opportunities, generating ideas, and developing concepts that can be transformed into future products, services, processes, or methods (Koen et al., 2001).

Some authors have already explored this theme together with the issue of collaboration, as there is a disseminated idea that no project is isolated and no company can succeed alone (Matinheikki, Artto, Peltokorpi, & Rajala, 2016), praising the importance of collaboration for innovation. As for collaborations, Tidd, Bessant, and Pavitt (2008) mention that companies collaborate for several reasons, such as reducing technological costs and development risk, reducing time spent developing and commercializing new products, and leveraging economies of scale or even promoting shared learning.

This last result is usually leveraged by the so-called network model, which is a dynamic strategy. The concept of innovation networks is currently popular "as it appears to offer many of the benefits of internal development, but with few of the drawbacks of collaboration" (Tidd, Bessant, & Pavitt, 2008, p. 327).

Baraldi, Havenvid, Linné, and Öberg (2019) conclude that networks are important, if not essential, in this context and show that there is still a need for a greater understanding of the interfaces between new ventures and networks. The study by Lilien et al. (2002, as cited in

Keinz & Pruegl, 2010) corroborates this importance by showing that internally generated new product ideas will lack novelty compared to new product ideas originating from the interaction with interested external actors.

For Chesbrough (2003, as cited in Brito & Leitão, 2020), open innovation uses knowledge inflows and outflows to accelerate internal innovation and expand markets, reinforcing the importance of acquiring external knowledge and innovation produced in a network. It is worth mentioning that the objective of networking is to seek "[...] to optimize the connectivity among people. It is to increase the extent and density of the network by strengthening existing connections, enabling new connections and getting a speedy response. It is to increase the network's potential to give rise to unexpected connections" (Wenger, Trayner, & Delaat, 2011, p. 12).

Therefore, social relationships can be represented as network structures in collaborative initiatives and can play a vital role in a better understanding of collaboration in knowledge initiatives, as reinforced by Takahashi, Indulska, and Steen (2018). This is necessary for the FEI since ideas in the early stages tend to lack sufficient information, a mark of the uncertainties of this stage. Moreover, "uncertainty demands the availability of a diverse network, reaching out to new people is as crucial for moving the process forward as reliance on pre-existing networks is for starting it" (Engel, Kaandorp, & Elfring, 2017, p. 43).

However, Wagner, Bican, & Brem (2021) reinforce that collaboration in the FEI must go beyond the simple communication and exchange of information for success in this stage. Gama, Frishammar, and Parida (2019) also reinforce that the literature is still unclear on how the involvement of external actors affects, for example, the relationship between the systematic generation of ideas and the performance of small companies' front end.

Therefore, entrepreneurial ecosystems worldwide have been investing in initiatives to support the ideation and validation processes of ideas. However, Brito and Leitão (2020) warn that studies that assess specific characteristics of entrepreneurial ecosystems do so based on the analysis of specific regions, evidencing the lack of greater clarity of the elements that may be common to different ecosystems regardless of the territory.

According to Cooke et al. (1997, as cited in Pittz, White, & Zoller, 2019, p. 10), "a high-performing entrepreneurial ecosystem leads to increased knowledge spillover and innovativeness." Thus, the activities developed at this stage of the innovative process require, among other things, seeking feedback from stakeholders, which can increase the acceptance of ideas (Kijkuit & Van Den Ende, 2007 as cited in Zhu, Kock, Wentker, & Leker, 2019). Thus,

Brito and Leitão (2020) reinforce that open innovation and co-creation are the foundations of creating value in ecosystems.

Methodology

A systematic review on the front end of innovation and collaboration was initially carried out to better understand the themes in this research. The review supported the elaboration of a theoretical framework for identifying, selecting, and critically evaluating studies on the subject (Cordeiro, Oliveira, Rentería, & Guimarães, 2007). The review offered elements to guide reflections and contribute to identifying opportunities for future research.

The databases researched were EBSCO, Scopus and Web of Science, currently considered the most relevant in the category of this study. The first step was carried out on April 22, 2020 and encompassed a search in the aforementioned databases, combining descriptors that represent the studied themes:

I. ((*"collabor*" OR "cooperat*" OR "colabora*" OR "coopera*") AND ("front end" OR "front-end" OR "front end of innovation"*))
II. ((*"collabor*" OR "cooperat*" OR "colabora*" OR "coopera*") AND ("front end" OR "front-end" OR "front end of innovation") AND ("innovation" OR "inovação"*))

The search found 2493 articles. The second step consisted of applying the filter of time of publication, selecting the articles published from 2010 onward. This procedure resulted in 1484 articles, which were subsequently filtered by categories related to the theme, as follows:

- In the EBSCO database*: information resources management; information theory management; case studies; collaborative learning; decision making; experimental design; human-computer interaction; and information technology.*
- In the Scopus database: *Business, Management and Accounting; Social Sciences; Multidisciplinary; Decision Sciences; Economics, Econometrics and Finance; Arts and Humanities.*
- In the *Web of Science database: management; social work; computer science interdisciplinary applications; business; interdisciplinary social sciences; multidisciplinary sciences.*

The sample of 464 articles obtained after applying the filter by categories was treated by excluding duplication. The remaining 290 articles were submitted to the next step of the systematic review.

This next step was the selection of the final sample studied. The titles, keywords, and abstracts of the 290 articles were read and analyzed, resulting in the exclusion of 243 articles that were not aligned with the objectives of the systematic review. At the end of this step, the sample was comprised of 43 documents.

A preliminary reading of the 43 studies selected in the first systematic review brought up new themes that, although peripheral, were considered relevant for the study. Among these new themes, the social network and the organizational network theories stood out (Gupta & Maltz, 2015; Jörgensen, Bergenholtz, Goduscheit, & Rasmussen, 2011; Matinheikki, et al., 2016; Parjanen, Hennala, & Konsti-laakso, 2012; Schoonmaker, Carayannis, & Rau, 2013), as did the knowledge theory (Bertels, Kleinschmidt, & Koen, 2011; Pateli & Lioukas, 2019; Sakellariou, Karantinou, & Goffin, 2017; Takahashi et al., 2018; Zhu, et al., 2019), along with ramifications of these theories.

The connection between the theme of networks and collaboration led to a new search in the same databases (EBSCO, Scopus, and Web of Science), including the descriptors "entrepreneurship" and "networks." This second search was conducted on October 11, 2020, using the search query: ((“entreprene*”) AND (“innovation” OR “innovation”) AND (“social network*”)). The inclusion of the descriptor "entrepreneurship" was a choice to offer a context in the search with the descriptor "networks," identifying the studies on networks within the perspective of innovation processes.

This second search in the databases found 833 articles. The same filtering procedures adopted in the first review were carried out to find the studies aligned with the themes addressed in this research:

I. The search filtering the articles published from 2010 onward reduced the sample to 729 studies;
II. Categories related to the theme, namely:
   A. EBSCO: *social networks; entrepreneurship; innovations in business; social capital; bibliometrics; business enterprises; economic development; business networks; business people; diffusion of innovations; network analysis (communication); online social networks; problem solving; small business; social entrepreneurship; social innovation; social network analysis; social network theory; business cycles; business*

incubators; business models; businessmen; businesswomen; capital investments; collective behavior; communities.

B. *Scopus: Business, Management and Accounting; Social Sciences; Multidisciplinary; Decision Sciences; and Economics, Econometrics, and Finance.*

C. *Web of Science: management; business; interdisciplinary social sciences; and computer science interdisciplinary applications.*

After applying the filters, the sample was reduced to 520 articles. Then, duplicate studies (when listed in more than one database) were excluded resulting in a sample of 441 studies, we read the titles, keywords, and abstracts read to assess their alignment with the research objective. At the end of this step, the sample consisted of 56 documents selected for step four of the process – reading the entire article and making notes. Table 1 summarizes the process, presenting the number of articles per database.

Table 1

Search per database

Search	Database	Descriptors	Date	Results
1	EBSCO	*(("collabor*" OR "cooperat*" OR "colabora*" OR "coopera*") AND ("front end" OR "front-end" OR "front end of innovation"))*	April 22, 2020	191
2	Scopus	*(("collabor*" OR "cooperat*" OR "colabora*" OR "coopera*") AND ("front end" OR "front-end" OR "front end of innovation"))*	April 22, 2020	1302
3	Web of science	*(("collabor*" OR "cooperat*" OR "colabora*" OR "coopera*") AND ("front end" OR "front-end" OR "front end of innovation"))*	April 22, 2020	791
4	EBSCO	*(("collabor*" OR "cooperat*" OR "colabora*" OR "coopera*") AND ("front end" OR "front-end" OR "front end of innovation") AND ("innovation" OR "inovação"))*	April 22, 2020	2
5	Scopus	*(("collabor*" OR "cooperat*" OR "colabora*" OR "coopera*") AND ("front end" OR "front-end" OR "front end of innovation") AND ("innovation" OR "inovação"))*	April 22, 2020	117
6	Web of science	*(("collabor*" OR "cooperat*" OR "colabora*" OR "coopera*") AND ("front end" OR "front-end" OR "front end of innovation") AND ("innovation" OR "inovação"))*	April 22, 2020	90
7	EBSCO	*(("entreprene*") AND ("innovation" OR "inovação") AND ("social network*"))*	October 11, 2020	62

Search	Database	Descriptors	Date	Results
8	Scopus	*(("entreprene*") AND ("innovation" OR "inovação") AND ("social network*"))*	October 11, 2020	357
9	Web of science	*(("entreprene*") AND ("innovation" OR "inovação") AND ("social network*"))*	October 11, 2020	414

Source: Elaborated by the authors, 2021.

The next step consisted of a manual process of extracting data from the articles and listing them in an Excel spreadsheet. The data extracted subsidized the elaboration of a word cloud using the Wordclouds software. Some articles were discarded during the manual data extraction or because the full manuscript was unavailable/could not be accessed, or the preliminary reading identified they did not fit the research objectives, or the study did not offer relevant elements justifying their contribution for the research:

- Searches 1 to 6: seven articles were unavailable and could not be accessed. Thirteen articles were discarded for not offering relevant contributions for the objectives of the research.
- Searches 7 to 9: out of the 56 articles, five were unavailable, 16 were discarded after a preliminary analysis for not being aligned with the research, and nine were identified as not relevant to the research.

Therefore, the final sample consisted of 49 articles – 23 from the first systematic review and 26 from the second. Figure 1 summarizes the process. After the two systematic reviews, the data of the 49 articles were systematized and analyzed, as presented in the next section. Table 2 summarizes the stages of the systematic review based on Pollock and Berge (2018).

Table 2

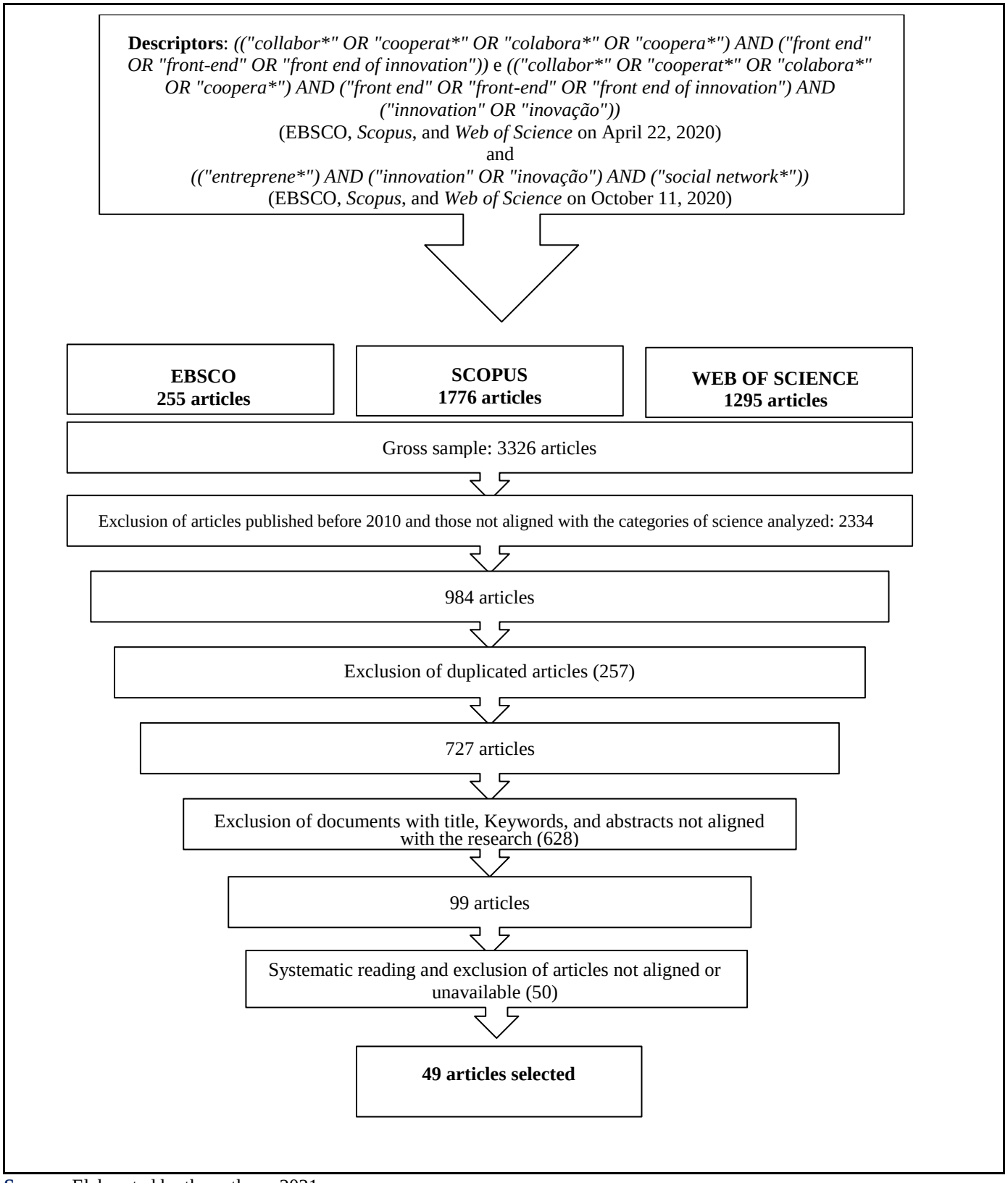
Key stages of the systematic review protocol

Stage 1 – Clarify aims and objectives	Defining research question Revising research question
Stage 2 – Find relevant research	Defining databases Defining search descriptors and query
Stage 3 – Collect data	Using filters according to categories related to the theme in the databases
Stage 4 – Assess the quality of studies	Preliminary evaluation of results Identification of peripheral themes Recombination of search descriptors Exclusion of duplicated articles or studies not aligned with the research
Stage 5 – Synthesize evidence	Data processing in an Excel spreadsheet
Stage 6 – Interpret findings	Data analysis based on the final sample

Source: Elaborated by the authors based on Pollock and Berge (2018).

Figure 1

Process of selection of articles in the systematic review



Source: Elaborated by the authors, 2021.

Results

This section offers an overview of the articles that form the final sample. The results show the representativeness of the journals publishing the articles, the distribution of the articles over the decade from 2010 to 2020, the most used keywords, the articles that had the highest number of citations, and the main discussions regarding the front end of innovation (FEI) and networks.

The journals with the most publications were Creativity and Innovation Management (four articles) and Journal of Product Innovation Management (three articles). Another four journals also present two articles each: International Journal of Innovation Management; Journal of Business Research; Journal of Technology Transfer; and Small Business Economics. The greatest concentration of articles was found in journals that deal with innovation, technology, and business management, especially small businesses, since one of the themes studied is entrepreneurship.

In addition, Table 3 shows the journals' representativeness according to the analysis conducted in the 2013-2016 quadrennium of Qualis (Brazilian journal ranking system) and the Journal Impact Factor (JIF) of 2019. Two journals ranked Qualis A1 and two Qualis A2. The other two journals (both from Springer) do not have data on Qualis but have a relevant impact score.

Table 3

Name of the journal, ISSN, publisher, country, Qualis, and JIF of the journals that published the most articles

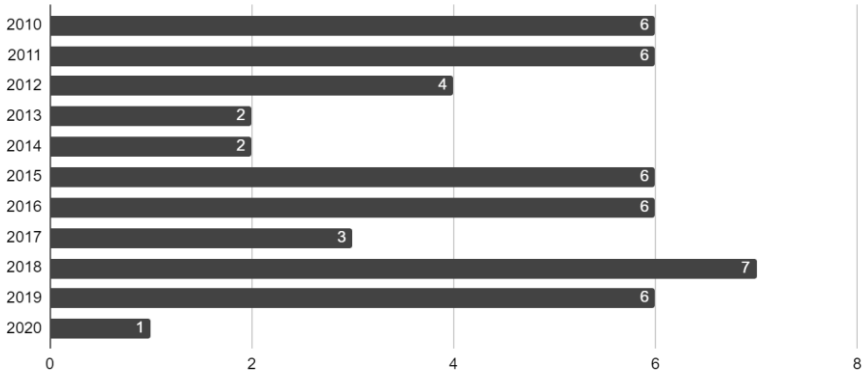
Journal	ISSN	Publisher	Country	Qualis	JIF 2019
Creativity & Innovation Management	0963-1690	Wiley	UK	A2	2.113
Journal of Product Innovation Management	0737-6782	Wiley	US	A1	5.000
International Journal of Innovation Management	1363-9196	World Scientific	Singapore	A2	-
Journal of Business Research	0148-2963	Elsevier Science Inc	US	A1	4.874
Journal of Technology Transfer	0892-9912	Springer	US	-	4.147
Small Business Economics	0921-898X	Springer	Netherlands	-	4.803

Note: Qualis ranking retrieved from https://sucupira.capes.gov.br/sucupira/public/consultas. Journal Impact Factor (JIF) retrieved from https://jcr.clarivate.com/JCRLandingPageAction.action.
Source: Elaborated by the authors, 2021.

Regarding the number of articles published in the last decade (Figure 2), it is possible to observe a balanced distribution over time. The year with the highest number of publications was 2018, with seven articles. Five years had the same total number of 6 articles (2010, 2011, 2015, 2016, and 2019). The most relevant articles within the studied themes were published from 2015 onwards, which demonstrates that the current research is supported by recent studies.

Figure 2

Articles published per year considering the selected articles



Source: Elaborated by the authors, 2021.

Figure 3 shows the most used keywords in the articles analyzed. The words "innovation," "social," "fuzzy front end," "knowledge," "collaboration," and "research" are highlighted, as represented in the word cloud below.

Figure 3

Keywords in the selected articles

Source: Elaborated by the authors, 2021.

Table 4 shows the articles cited more than 50 times according to Google Scholar. Fourteen articles matched this condition out of the 49 selected. Two of these 14 articles were published in the journal Creativity and Innovation Management, which is the journal that published the most articles analyzed in this study.

Table 4

Most cited articles

Citations	Year	Authors	Title	Journal
399	2017	Alvedalen, Janna Boschma, Ron	*A critical review of entrepreneurial ecosystems research: towards a future research agenda.*	*European Planning Studies*
366	2018	Spigel, Ben Harrison, Richard	*Toward a process theory of entrepreneurial ecosystems*	*Strategic Entrepreneurship Journal*
284	2015	Huggins, Robert Thompson, Piers	*Entrepreneurship, innovation and regional growth: a network theory*	*Small Business Economics*
235	2010	Hindle, Kevin	*How community context affects entrepreneurial process: A diagnostic framework*	*Entrepreneurship and Regional Development*
192	2014	Leyden, Dennis P Link, Albert N Siegel, Donald S	*A theoretical analysis of the role of social networks in entrepreneurship*	*Research Policy*
150	2017	Engel, Yuval Kaandorp, Mariette Elfring, Torn	*Toward a dynamic process model of entrepreneurial networking under uncertainty*	*Journal of Business Venturing*
120	2011	Bertels, Heidi M J Kleinschmidt, Elko J Koen, Peter A	*Communities of Practice versus Organizational Climate: Which One Matters More to Dispersed Collaboration in the Front End of Innovation?*	*Journal of Product Innovation Management*
113	2016	Matinheikki, Juri Artto, Karlos Peltokorpi, Antti Rajala, Risto	*Managing inter-organizational networks for value creation in the front-end of projects*	*International Journal of Project Development*
95	2015	Eftekhari, Nazanin Bogers, Marcel	*Open for Entrepreneurship: How Open Innovation Can Foster New Venture Creation*	*Creativity and Innovation Management*
77	2018	Shu, Rui Ren, Shenggang Zheng, Yi	*Building networks into discovery: The link between entrepreneur network capability and entrepreneurial opportunity discovery*	*Journal of Business Research*
75	2011	Dodgson, Mark	*Exploring new combinations in innovation and entrepreneurship: social networks, Schumpeter, and the case of Josiah Wedgwood (1730-1795)*	*Industrial and Corporate Change*
59	2016	Takey, Silvia Mayumi Carvalho, Marly M	*Fuzzy front end of systemic innovations: A conceptual framework based on a systematic literature review*	*Technological Forecasting and Social Change*
52	2016	Nieto, Mariano Gonzalez-Alvarez, Nuria	*Social capital effects on the discovery and exploitation of entrepreneurial opportunities*	*International Entrepreneurship and Management Journal*
51	2010	Keinz, Peter Pruegl, Reinhard	*A User Community-Based Approach to Leveraging Technological Competences: An Exploratory Case Study of a Technology Start-Up from MIT*	*Creativity and Innovation Management*

Note: Number of citations retrieved on June 17, 2021, from https://scholar.google.com.br/scholar?q=.
Source: Elaborated by the authors, 2021.

Another 14 articles out of the 49 selected included the theme of FEI in their bibliographic review. Among these 14 articles, the authors/articles cited more often – and, therefore, considered references on the subject – are Koen et al. (2001, 2002); Khurana and Rosenthal (1997, 1998); Kim and Wilemon (2002); Cooper (1988, 1990, 2001); Reid and Brentani (2004); Smith and Reinertsen (1991).

The reflections these authors carried out when addressing the theme of collaboration in the FEI brought up peripheral, although relevant, themes. These topics led to a second theoretical immersion carried out in this study. Table 5 presents the peripheral themes identified, which reveal interconnection among themselves – as in the case of the organizational knowledge network, which includes the concepts of network and knowledge.

Table 5

Peripheral themes from the first systematic review

Themes	Sub-themes	Authors
Social networks	Social interaction	Gupta, Maltz (2015).
	Interorganizational network	Jörgensen, Bergenholtz, Goduscheit, & Rasmussen (2011); Matinheikki, Artto, Peltokorpi, & Rajala (2016).
	Networks	Parjanen, Hennala, & Konsti-laakso, (2012); Schoonmaker, Carayannis, & Rau (2013).
Knowledge theory	Tacit and explicit knowledge	Bertels, Kleinschmidt, & Koen (2011); Sakellariou, Karantinou, & Goffin (2017).
	Organizational knowledge network	Zhu, Kock, Wentker, & Leker (2019).
	Knowledge transfer	Pateli & Lioukas (2019); Takahashi, Indulska, & Steen (2018).
Innovation	Systemic innovation	Takey & Carvalho (2016).
	Open innovation	Gama, Frishammar, & Parida, (2019); Keinz & Pruegl (2010); Lau, Hirsch, Matheis, Fischer, & Kettemann (2016); Pateli & Lioukas (2019); Takahashi, Indulska, & Steen (2018).

Source: Elaborated by the authors, 2020.

Of the articles that deal with the FEI in their bibliographic review, six delve deeper into peripheral themes within the context of innovation, such as systemic and open innovation; five of them explore themes within the theory of knowledge; and five mention themes of social networks.

The theme of knowledge is frequent in the literature on collaboration at the FEI. In this context, it encompasses resources such as intangible capital (Alvedalen & Boschma, 2017;

Baraldi et al., 2019; Eftekhari & Bogers, 2015; Engel et al., 2017; McGrath, O'Toole, Marino, & Sutton-Brady, 2018; Nieto & Gonzalez-Alvarez, 2016; Shu, Ren, & Zheng, 2018; Spigel & Harrison, 2018; Takahashi et al., 2018; Yao, 2011), which comprises new knowledge, skills, perspectives, or acquired ideas; tangible capital (Eftekhari & Bogers, 2015; Engel et al., 2017; Spigel & Harrison, 2018; Yao, 2011), in terms of resources such as information, documents, tools, and specific procedures; and assets and actions that promote the collective voice of network members (Alvedalen & Boschma, 2017; Brito & Leitão, 2020; Hindle, 2010; Matinheikki et al., 2016; Nieto & Gonzalez-Alvarez, 2016; Xu, 2011).

Authors such as Amabile (1988) and Polanyi (1966, as cited in Bertels et al., 2011) claim that low levels of tacit knowledge are especially problematic at the FEI because of its high degrees of uncertainty and requirements for creativity. New combined knowledge supports the process of developing innovative ideas at the FEI (Sakellariou et al., 2017).

However, Takey and Carvalho (2016) mention there is still a gap in studies on the FEI that consider external variables and stakeholders to the organization (environmental factors) to understand this initial stage of the innovation process. Few studies address the relevance of stakeholder involvement at the FEI (Bendavid & Bourgault, 2010).

However, studies have pointed out that external knowledge in the process of evaluating an idea may lead to other perspectives, facilitating the identification of strengths and weaknesses that can support the decision-making process about taking the idea forward or not – the so-called go/no go (Lau et al., 2016). Therefore, collaboration with external actors and interaction within the organization is a significant indication of knowledge transfer and a relevant point in obtaining new ideas for the initial process of the FEI (Takahashi et al., 2018).

Furthermore, "knowledge obtained from a social network helps entrepreneurs to achieve business information and seize business opportunities, and eventually leads to entrepreneurs' innovativeness" (Jiao, Cui, Zhu, & Chen, 2014, p. 504). Therefore, the research deepened the knowledge on the theme of networks associated with innovative entrepreneurship to better explore how networks can support collaboration at the FEI. Furthermore, Dodgson (2011, p. 1120) mentions that "the literature on social networks commonly refers to Schumpeter's identification of the importance of new combinations for innovation and entrepreneurship."

Among the aspects that influence a network, elements of the local geographic community impact the development of networks in the context of entrepreneurship, such as culture (Baraldi et al., 2019; Brito & Leitão, 2020; Hindle, 2010; Nieto & Gonzalez-Alvarez, 2016; Pittz et al., 2019; Spigel & Harrison, 2018), characterized by shared actions and behaviors

that inspire people. Brito and Leitão (2020, p. 5) mentioned that works such as Feld (2012) and Isenberg (2010) raised the idea that local culture can "have a significant impact on the entrepreneurial process."

Some material aspects were also mentioned in the articles selected (Alvedalen & Boschma, 2017; Baraldi et al., 2019; Brito & Leitão, 2020; McGrath et al., 2018; Spigel & Harrison, 2018), such as institutions and organizations of a given region that support and foster entrepreneurship, whether through financial resources, facilities, laboratories, collective spaces, among others.

Among the discussions in the articles, some aspects affect the relationships or ties between actors in a network, such as the individual predispositions that lead an actor to participate in a network (Engel et al., 2017; Matinheikki et al., 2016; Rossano-rivero & Wakkee, 2019). Motivation is rarely addressed explicitly in network studies. However, as the field moves toward recognizing the power of individual actors, interactions between motivation and network variables are likely to play a central role (Casciaro et al., 2015, as cited in Engel et al., 2017).

The studies also discussed how relationships between network members are established and maintained and the strength of their ties (Alvedalen & Boschma, 2017; Baraldi et al., 2019; Burström, Harri, & Wilson, 2018; Dodgson, 2011; Hindle, 2010). The debate on the formation of links between members of a network is extensive, traditionally dealing with the role of weak and strong ties based on Granovetter's theory (1973 as cited in Burström et al., 2018, p. 54), which defines the strength of a tie as "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie."

Finally, in the case of new product development, Hansen (1999, as cited in Dodgson, 2011, p. 1122) "shows weak ties assist the search for innovation opportunities and strong ties assist the transfer of complex knowledge." Reagans and McEvily (2003, as cited in Di Fatta, Caputo, & Dominici, 2018) address the lack of comprehension regarding the quality of ecosystem relationships to explore issues of knowledge exchange in innovation.

Discussion

The authors/articles with the highest number of citations regarding the front end of innovation (FEI) are Koen et al. (2001, 2002), Khurana and Rosenthal (1997, 1998), Kim and Wilemon (2002), Cooper (1988, 1990, 2001), Reid and Brentani (2004), Smith and Reinertsen

(1991). When considering collaboration at the FEI, the peripheral themes that emerge from the articles in this context, including interconnection, are "social networks," "theory of knowledge," and "open innovation."

Among the aspects that influence a network (entrepreneurial network, in the context of this article), the main elements of the local geographic community that impact the development of networks are grouped into cultural (Baraldi et al., 2019; Brito & Leitão, 2020; Hindle, 2010; Nieto & Gonzalez-Alvarez, 2016; Pittz et al., 2019; Spigel & Harrison, 2018) and material (Alvedalen & Boschma, 2017; Baraldi et al., 2019; Brito & Leitão, 2020; McGrath et al., 2018; Spigel & Harrison, 2018). Brito and Leitão (2020) show that studies that assess specific characteristics of entrepreneurial ecosystems do so from the analysis of specific regions. However, it is still necessary to explore how these characteristics vary across regions and, for example, what type of institutions are relevant to form these entrepreneurial networks.

In addition, the articles discuss aspects that affect the relationships or ties among actors in a network, such as the individual motivations that lead a person to participate in a network (Matinheikki et al., 2016; Engel et al., 2017; Rossano-rivero & Wakkee, 2019), how relationships between network members are established and maintained, and the strength of the ties created (Alvedalen & Boschma, 2017; Baraldi et al., 2019; Burström et al., 2018; Dodgson, 2011; Hindle, 2010).

Therefore, this article contributes to studies focused on the theme of networks, especially focused on collaboration that support the FEI. However, the research was limited to understanding networks in entrepreneurship, which opens the possibility for analysis in other contexts.

Furthermore, although understanding that collaborative networks – which promote informal communication to the development of ideas – can increase interaction and creativity (Leenders et al., 2002; Leenders, Van Engelen, & Kratzer, 2003 as cited in Parjanen et al., 2002), it is unclear what are best practices to promote collaboration at the FEI, especially with a view to the development of networks to foster innovative entrepreneurship. Wagner, Bican, & Brem (2021) reinforce that for positive effects in a collaboration at the FEI, it is important for it to exceed the simple communication and exchange of information. This is a field that needs further research.

Baraldi et al. (2019) suggest that future studies focus on the negative points for the development of enterprises when participating in a network since studies tend to concentrate only on positive elements. Gama, Frishammar, and Parida (2019) reinforce that further studies

are needed to understand when external market contributions are positive for certain stages of the FEI (such as idea generation), as the internal level of maturity of the process influences the impact of contributions.

For Burström et al. (2018, p. 57), "there is a lack of empirical studies explaining tie formation and the networking behavior in the very early stages of venture development." This further expands the possibilities for future studies as proposed in this article. A final suggestion for future research is to expand the understanding of the collaboration at the FEI in the perspective of the theory of knowledge, one of the peripheral themes identified as relevant during the first systematic review conducted in this study.

From the point of view of social contributions, it was possible to identify elements that influence a network, such as the cultural and material structure of the region and the relationships established in the network, especially individual predispositions and the strength of the ties developed. The limitations of this research include the fact that the analyzed results are restricted to the databases used.

Authors' contributions

Contribution	Ferreira, C.	Lemos, D. da C.
Contextualization	X	X
Methodology	X	X
Software	X	------
Validation	X	X
Formal analysis	X	------
Investigation	X	------
Resources	X	X
Data curation	X	------
Originality	X	------
Revision and editing	X	X
Visualization	X	------
Supervision	X	X
Project management	X	X
Financial acquisition	X	X

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